16-453

Glass Optimization

Field of the Invention

The present invention concerns apparatus and method for cutting glass lites from large sheets of glass to achieve the highest yield.

Cross Reference to Related Application

The present application claims priority from United States Provisional application serial no. 60/472,060, entitled "Window or Door Glass Optimization" filed May 20, 2003.

Background Art

A manufacturer of products that incorporates glass, such as a window manufacturer, receives orders for products which require different sizes of glass lites. The orders for the glass are separated and grouped into scheduled production batches. For each production batch, the glass lites are further grouped and arranged to be cut from large stock glass sheets to achieve the highest yield. The process of grouping and arranging glass lites to be cut from stock glass sheets to achieve the highest yield is called glass optimization.

Glass optimization is usually performed by a computer executing a computer program one hour to one day prior to use at the cutting station. The output from the glass optimization process is a control program that is sent to a computer-controlled cutting table. The glass optimization software outputs a computer program that optimizes one or more production batches containing patterns of lites arranged on stock glass sheets. The cutting table automatically scores the glass according to each pattern. Each production batch normally contains one or more glass layout patterns that provide a lower yield than desirable.

These Low Yield Patterns or Low Yield Sheets significantly reduce the yield of entire production batches resulting in higher manufacturing costs due to wasted glass. Waste is particularly expensive when manufacturing windows from increasingly popular specialty glasses such as Low-E or self-cleaning materials.

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Today, there are several existing methodologies used to increase glass yields. Unfortunately, each method presents one or more problems to manufacturing operations. The methods and their resulting problems are described below.

a) Standard dimensioned lites called filler lites can be introduced to scheduled production batches to fill-in unused space on the stock glass sheets. The glass optimization software determines where filler lites can be inserted when creating the initial programmed patterns. Because fillers are inserted prior to the actual manufacturing process, the number and type of filler lites rarely meet actual production demand. Too few filler lites starve production lines while too many fillers create storage and quality problems.

b) Adding different sizes of large stock sheets also increase yield. This allows the glass optimization software to pick the size of stock sheets that produce the best yield. Although this method enhances yield, it also increases inventory space and costs while decreasing throughput (more glass sizes to shuttle in and out).

c) Certain cutting tables allow the lites from Low Yield Sheets to be added to manually entered or selected lites and re-optimized to increase yields. Although these features provide excellent flexibility and increase yield, they also cause the cutting table to remain idle during the manual entry process. This greatly reduced production throughput and efficiency.

Summary of the Invention

A system is disclosed for heuristically optimizing the arrangement of lites to be cut from said glass sheets. The system defines a number of batches wherein each batch requires a specified number and type of glass lites. The system lays out patterns of lites to be cut from large stock glass sheets to fulfill the lite requirements for the first batch within the number of batches.

The system also identifies one or more underutilized glass sheets in the first batch that have free space with no lites left to be cut in the first batch. The system also lays out a pattern of lites to be cut to fulfill the lite requirements of one or more additional batches in the number of batches by utilizing at least some of the free space on the underutilized glass sheets of the first

batch. Additionally the system designates other glass sheets from which to cut other lites in the additional batches.

Practice of the invention significantly increases yield without the problems associated with existing methodologies discussed above such as inadequate supply, excessive inventory costs, increased storage requirements, decreased quality and reduced production throughput.

These and other objects and advantages of the system constructed in accordance with an exemplary embodiment of the invention is more completely described in conjunction with the accompanying drawings.

Brief Description of the drawings.

Figure 1 is a schematic representation of a cutting station located within a window or door manufacturing facility;

Figure 2 is a schematic of a user interface by means of which an operator sets up cutting operations at the Figure 1 cutting station;

Figures 3-9 are schematic depictions of glass sheets illustrating layouts of lites to be cut from the sheets at the cutting station; and

Figures 10A and 10B are flowcharts for optimizing lite layouts on glass sheets of a production ~~run~~ batch.

Best mode for practicing the invention

The disclosed invention provides an integrated software and apparatus solution for increasing the yield of production runs during window or door manufacture, or other manufacture requiring glass lites. An exemplary system automatically recognizes and optimizes Low Yield Sheets by adding glass lites from other production batches as well as lites entered or selected at a cutting station 10. The exemplary system also automatically creates, tracks, selects and re-cuts remnant sheets of glass if the process is unable to add sufficient lites to eliminate Low Yield Sheets from a production batch.

The Figure 1 cutting station 10 includes a controller 12 that provides the cutting station operator an option of easily selecting filler lite sizes that can be automatically inserted into each production batch. The controller is coupled to a display or breakout monitor 14 that graphically alerts the cutting table operator(s) which cart and slot to place each lite as it is cut. The

controller 12 and breakout monitor 14 also graphically alert the cutting table operator(s) where to place or remove remnant sheets for subsequent processing. The controller and breakout monitor also graphically alert the cutting table operator(s) which temporary cart slot to place or remove lites for subsequent processing.

In addition, the system tracks and reports yield, throughput and filler lite information in real-time to the cutting table display or monitor 14 as well as other computers by means of a network 16 which allows the controller 12 to communicate with other computers in the manufacturing facility. These other computers include computer-controlled manufacturing devices at other workstations and computer software for controller the entire manufacturing process.

Figure 1 depicts representative apparatus for optimizing the fabrication of products that include lites cut from said glass sheets. The cutting station 10 including a moveable cutting head 20 supported for movement with respect to a glass sheet 22 (Figure 3) positioned on a cutting table 24 with respect to the cutting head 20 from which glass lites are cut. The same controller 12 that updates the display or monitor 14 is also responsible for controlling the movement with respect to the cutting table of the cutting head 20.

Figure 3 shows a representative sheet 22 having a number of lites 30 – 33 scheduled to be cut from specified locations on the sheet 22. Typical dimensions (prior to cutting) for a sheet such as the sheet 22 shown in Figure 3 are 72 inches by 84 inches. Other standard sizes are 96" by 130" and 48" by 60".

The sheet 22 is removed by an operator from one of two racks 40, 41 (Figure 1) positioned in relation to the cutting table 24. The sheet is placed on its edge at the side or at the end of a free fall table 42. The table 42 has a relatively smooth and soft top surface onto which the glass sheet falls. From its position on the table the sheet is automatically transferred to the cutting table 24. While on the cutting table 24 the sheet 22 is cut by the cutting head and then moved to a break out table 44. At the break out table 44 an operator breaks out the lites from the glass sheet 22.

As seen in Figure 1, a number of carts 50-53 are positioned with respect to the cutting station 10 for storing lites as they are cut from a glass sheet 22 by the cutting head 20. The controller 12 or another ancillary computer includes software running on a processor which performs a number of tasks used by the system for making the glass cutting process more

efficient. The controller lists a number of batches wherein each batch requires a specified number and type of glass lites for use in fabricating products in an associated batch. The controller 12 (or ancillary computer) and breakout monitor 14 displays a pattern of lites to be cut from a first set of glass sheets to fulfill the lite requirements for one batch and during cutting prompts the operator to place the lites for that batch into a single one of the four carts 50 – 53.

The controller 12 or ancillary computer is capable of recognizing and adjusting to under utilized glass sheets. In accordance with one exemplary embodiment of the invention, under utilized glass sheet is any sheet where less than 70 % of the sheet has lites allocated for a given batch. The sheet 22 depicted in Figure 3 is an underutilized glass sheet having free space 60 with no lites designated to be cut for the batch that the sheet 22 is associated with. The four lites 30 that have been designated for a particular batch have been labeled with the designation "P" to indicate that they are associated with a particular production batch. These four lites 30-33 take up much less than the 70 % cutoff.

As explained more fully below, the controller 12 or ancillary computer responds to recognition of such an underutilized sheet by laying out a pattern of lites to be cut to fulfill other lite requirements, possibly the other requirements one or more additional batches in a queue of such batches. The controller utilizes at least some of the free space 60 on the underutilized glass sheets of a first batch by designating usage of the free space 60 for other batches. The controller 12 or ancillary computer then completes the designated lites for those other or subsequent batches by laying out other glass sheets from which to cut other lites in that subsequent batch(es). This process, of course, takes into account the lites that have already been designated from the underutilized sheet or sheets of the previous batch or batches.

Theory of Operation

The software running on the controller or ancillary computer begins heuristically optimizing a next production batch in a queue of such batches by identifying a Low Yield Sheet if it exists. The controller or ancillary computer automatically calculates how to fill the sheet according to a list of priorities exemplified by the flowchart 110 in Figures 10A and 10B. To help illustrate the process of Figures 10A and 10B, in Figures 3 – 9 the glass lites are labeled with designators depending on where in the list of priorities these lites are identified for inclusion onto a Low Yield Sheet.

The highest priority is a regular production batch lite P. A next highest priority is a local remake or MDI lite L. Three such lites 31 are depicted in Figure 4. An MDI lite is typically made in response to a request due to breakage or a prior knowledge of a need by the cutting station operator. MDI lite information is entered by the operator at controller 12 using a keypad. A local remake is typically required because a lite is broken at the cutting table. Local remake information is entered by the operator using pushbuttons to highlight the lite that needs to be replaced on the breakout monitor or on the controller display.

A next highest priority lite inserted into the Low Yield Sheet is a production run look ahead lite LA. Two such lites 32 are depicted in Figure 5. A typical manufacturing sequence of batches will have need for lites from the same type of glass in multiple batches. The system recognizes this need by inserting lites for subsequent batches on a Low Yield Sheet. These are called look ahead lites LA because the system "looks ahead" to subsequent batches for lites to add to a Low Yield Sheet. As the operator breaks out the lites from a sheet the viewing monitor 14 tells the operator where he or she should put that look ahead lite. This is typically in the form of a cart slot number at the cutting station.

The next priority lite added to a Low Yield Sheet is a filler lite F. Filler lites are certain sizes and glass types that are commonly used in production. The system adds filler lites to Low Yield Sheets to increase yield. They are stored in close proximity to the cutting table. The number of filler lites needed is noted on the display. (See figure 2) As the number of filler lites that have been cut increases, the corresponding number of filler lites that are needed decreases and the video display will be updated until the desired number of filler lites has been cut. When a production batch calls for a lite with the size and glass type of a filler lite, an appropriate filler lite can be quickly retrieved from the storage area. Although the depictions of Figures 3-9 suggest that the controller places lites of a similar nature together on the glass sheet, the controller may rearrange the lites on a pattern to increase yield and may for example intersperse lites of different types next each other on the glass sheet.

The next priority added to a Low Yield Sheet is a temporary lite T. A temporary lite is designated as a lite to be stored in a temporary cart until a cart for it's production batch has been placed at the cutting table in the positions illustrated in Figure 1 by carts 50, 51, 52, or 53.

The next priority added to a Low Yield Sheet is a remnant R. A remnant is designated as the remaining area of the large stock glass sheet that can be stored and used later in the

optimization process. The invention will instruct the cutting table if and how to cut the remnant for easier storage and store the position and size information of the remnant for subsequent optimization.

During the optimization process 110 (which takes place prior to cutting) depicted in the flow chart of Figures 10A and 10B, the controller optimizes glass usage to reduce waste during glass cutting utilizing the sequence of priorities. The invention may also heuristically change the sequence of priorities based on input gathered via a computer network from other machines or programmable devices.

The cutting table operator presses 112 a function key on the controller. The controller responds by displaying 114 a graphical display 70 similar to Figure 2. Listed on the display 70 is a Production Run Look-Ahead Parameter 72. This parameter corresponds to how many production batches the controller will look-ahead for lites to increase the yield on Low Yield Sheets. The yield (as a percentage) that the controller uses to determine a Low Yield Sheet is entered during the initial setup of the invention. Each production run typically corresponds to one cart. Therefore, if the Production Run Look-Ahead parameter displays the number '3', the operator knows to place 116 three carts 50, 51, 52 around the cutting table.

The display 70 (Figure 2) also includes a Temporary Cart Look-Ahead Parameter 74. If a number other than 0 is displayed, the operator places 118 a temporary cart or carts (cart 53 for example) at the cutting table. The displayed parameter indicates the number of additional production runs (in addition to the production run look ahead) to be checked with the look-ahead function. Assuming the temporary cart look ahead is other than zero, the Breakout Monitor will display which slot in the temporary cart the operator should place the lites identified from those production batches. In a typical application there is only one temporary cart for storing lites from multiple additional batches. When those additional batches are cut, the operator is prompted to move an already cut lite from its slot in the temporary cart and moved to its appropriate (and now in place) production run cart location or slot.

The operator views the Filler Lites Needed table 76 and enters the desired number of filler lites. Whenever possible, the invention adds the sizes of filler requested to Low Yield Sheet until the requested amount of filler lites is satisfied.

The operator views the Auto Sequencing Parameter. If "off", the operator cannot change the order of the production batches in the queue. The order of the production batches will be

determined by external software. If "on", the operator may rearrange 122 the order of any production batches not started. Color coding of the display of Figure 2 indicates which production batches in a list 80 are not started.

The operator then presses 124 the cycle start button. The cutting table will begin the next production run in the queue. The invention automatically identifies Low Yield Sheets and will calculate how to get the best yield. The sequence of steps 130 depicted in Figure 10B inform the operator which type of sheet to drop on the cutting table. The invention will follow a user-defined sequence of priorities to determine how to increase the yield by adding lites to the Low Yield Sheet from different sources. The invention adds lites from MDI (manual data input), local remake entry, future production runs and standard sizes (filler lites). The invention may also heuristically change the sequence of priorities based on input gathered via a computer network from other machines or programmable devices. If any Low Yield Sheets remain and the Remnant Management Parameter is "on", the invention will determine if the lites on the low yield sheet can more efficiently fit on a stored remnant sheet in a manner that eliminates the low yield condition. If so, the controller and breakout monitor alert the operator to load the corresponding stored remnant sheet from a remnant storage and retrieval system 45 having a cart for storing remnant sheets. The size and configuration of the Remnant Sheet Queue will be entered during the initial setup of the invention.

After the cutting table scores the sheet and it remains a Low Yield Sheets and the Remnant Management Parameter is "on" and there is room to store another remnant sheet on the remnant sheet cart, the system scores the largest rectangle possible in the unused area of the Low Yield Pattern. Via the breakout monitor, the system alerts the operator to transfer the remnant sheet to a manual, semi-automatic or automatic remnant storage and retrieval system 45. The breakout monitor also indicates which cart and slot (standard or temporary cart) to place each lite via text and color coding.

The operator presses another function key at the cutting table controller to return to the previous screen.

The invention also tracks and reports yield, throughput and filler lite information in real-time to the cutting table display as well as other computers, computer-controlled devices and computer software.

Although an exemplary embodiment of the invention has been described with a degree of particularity, it is the intent that the invention include all modifications and alterations from the disclosed design falling within the spirit or scope of the appended claims.